In the central section of the stretch studied by Shepard (Canal Flats to Bull River) there appears to be no relation between the trend of the trench and the structural lines. From this fact and the great width of this part of the trench, greater age is inferred, such as would be associated with a peneplaned surface where drainage had freed itself from the bondage of earlier structural and topographic controls.

### Drift of the Earth's Crust and Displacement of the Pole

Alfred Wegener. **Die Entstehung der Kontinente und Ozeane.** 2nd edit. viii and 135 pp.; maps, diagrs., index. *Die Wissenschaft: Sammlung von Einzeldarstellungen aus den Gebieten der Naturwissenschaft und der Technik No. 66.* Friedr. Vieweg & Son, Brunswick, 1920.

Wladimir Köppen. **Polwanderungen, Verschiebungen der Kontinente und Klimageschichte.** Maps, diagrs. *Petermanns Mitt.*, Vol. 67, 1921, January-February, pp. 1–8; March, pp. 57–63.

Wladimir Köppen. **Ursachen und Wirkungen der Kontinentenverschiebungen und Polwanderungen.** Diagrs. *Petermanns Mitt.*, Vol. 67, 1921, July–August, pp. 145–149; September, pp. 191–194.

The authors are meteorologists stationed at the Marine Observatory at Hamburg; they have apparently worked more or less in conjunction and cover very much the same ground in their publications. Wegener is more detailed in his description of the displacements of the continents; Köppen, of the changes of the earth's axis of rotation. The picture they present of the history of the earth's crust is as follows. The material of the upper 1,500 kilometers of the earth's crust is of two kinds, Suess' *sima* (rock rich in magnesium) and *sial* (rich in aluminium), Suess' *sal.* The latter is less dense than the former, is very much less in amount, and floats in it as icebergs float in water. The authors draw confirmation of this idea from the hypsometric curve, and Wegener gives a rather striking diagram of the relative areas at different levels of the lithosphere, showing the preponderance of a continental and an oceanic plateau, as first described by Murray. The sima is highly viscous and reacts as a solid to temporary forces but yields to long-continued forces. The sial is much more rigid and, though capable of being folded, is more apt to fracture. At the beginning of geological time, the sima layer was entirely covered by a mantle of sial about 30 kilometers thick. For some reason not given, this broke up and the sial collected together in a single mass (with some gaps), about 100 kilometers thick, to form the continents. Then the process was reversed, and one part after another broke away and floated off, with the result finally of the present distribution of the continents. By selecting the times of the various disruptions, by assuming great changes in the position of the earth's poles, and by introducing other hypotheses where needed the authors attempt to account for the variations in geological climates, for the distribution of former and recent fauna and flora, for glaciation and for many mountain chains. During Carboniferous and Permian times the disruption had scarcely started: the American continents were in contact with Europe and Africa; the latter, Antarctica, Australia, and India (which then stretched far to the south) were continuous; and the south pole of the earth lay in southern Africa. The existence of a common Permian glaciation in these countries is thus accounted for, for the authors think that strong glaciation is due to nearness to a pole lying in a land area. They overlook the evidence of glaciation in the mid-Carboniferous in Oklahoma and in the Permian in Massachusetts, England, and Germany—regions which were then quite close to their equator. Some similarities in the geological fauna and flora of the southern areas are also explained by their juxtaposition. The two parts of the Hercynian mountain range of the eastern and western hemispheres were united, as the north Atlantic ocean had not yet been formed. In the Eocene, things began to happen. Taking Africa as our point of reference, we may consider it at rest; Australia broke away and moved off to the east; Antarctica slipped off to the south; India to the northeast, crumpling up the mass in front of it to form the Himalayas; South America began to pull away from South Africa; but it was not until the Quaternary that northeastern North America, Greenland, and northwestern Europe were torn apart. Hence the distribution of glaciation during the Pleistocene ice age in the two continents, for, at that time, the north pole is supposed to have been in the present north Atlantic and about 20° from its present position.

Wegener is quite right in saying that in reconstructing the geography before the folding of a mountain range the greater area required by the smoothing out of the folds should be considered, a point not sufficiently taken into account by paleogeographers; but he is wrong in supposing that the Himalayas were folded in the Tertiary; they were elevated in this period, but the folding was earlier.

The continents being formed of light sial stood higher than the ocean basins, which consisted of sima. Therefore the centrifugal force due to the earth's rotation would tend to move them towards the equator. We find no calculations to show the competency of this force, but it is quite certain, according to the map drawn by Wegener, that the continents never did cluster about the equator. On the contrary, their general drift is supposed to have been westward. It is suggested that this westward drift may be due to the same cause as the westward direction of the trade winds, namely, the influence of the rotating earth on matter approaching the equator. But the authors do not claim that the American continents have shown any definite movement toward the equator; so the suggested explanation of the westward drift is inapplicable.

Wegener finds confirmation of the western drift of Greenland in the determinations of longitude made there in 1823, 1870, and 1907 by Sabine, Payer, and Koch respectively. They apparently show a westward movement of Greenland averaging 9 meters a year during the first interval and 32 during the second. The observations were made on the east coast of Greenland in latitude about 75° N., and the changes of longitude found seem to be outside the errors of observation. Foldings of the strata and the great overthrust faults teach us that parts of the lithosphere do move horizontally, and we have definite measures of movements along the western coast of the United States and in the island of Sumatra. If the movement of this part of Greenland should be confirmed, it would naturally be classed with those mentioned; but it would not indicate a general westward drift of the Americas. A movement of 32 meters a year is of the order of movement of the ice of moderately large Alpine glaciers; it is 500 times as large as the measured movement on the Pacific coast.

The resistance the sima of the ocean bed of the Pacific Ocean offered to the western drift caused a folding and crumpling up of the western border of the Americas, forming the Andes and the western mountains of North America. The same objection applies to this case as to the Himalayas; the folding occurred earlier. The great deeps along the South American coast are supposed to be due to the sinking of the sima to allow the lighter sial to pass over it. Experience indicates that the pressure of a moving mass would cause an elevation of a viscous substance in front of it. Where mountain ranges are formed away from the front of a moving continent, such as those of central Asia, they are supposed to be due to variations in the friction in the sima below. The ocean bottom is supposed to be smooth and featureless—an old idea, which modern soundings do not confirm. It is supposed to be free from foldings; of this we are entirely ignorant. The group of festooned islands off the eastern coast of Asia, together with the Antilles, are supposed to have been broken off and held back by special friction from the westward-drifting continents. The Atlantic islands are supposed to be carried off from Africa by special currents in the sima. The mid-Atlantic ridge is supposed to be formed by deposits when only a narrow strait had been formed between Africa and South America; but the ridge is far from either continent. The elasticity of the hypothesis is evident.

The authors accept the principle of isostasy, as indeed their general hypothesis requires; but they do not hesitate to assume lack of isostatic adjustment where it is indicated by their hypothesis. As we have not properly reduced gravity measures in these regions, the matter cannot be tested. When mountain ranges are formed by compression the lighter sial is forced down as well as up to satisfy isostasy. This is Osmond Fisher's idea, based on Airy's paper of 1855. The objection to it is that, at any rate many mountain ranges were elevated long after they were folded (see a paper on "Isostasy and Earth Movements," *Bull. Geol. Soc. of Amer.*, Vol. 33, 1922, pp. 317–326).

The explanation of the geologic climates by the displacement of the pole has been a favorite speculation of many geologists; and our authors use it to the full. The distance between the positions of the pole in the Carboniferous and in the Pleistocene would, according to them, be about 65°; but the length of the path followed from the former time to the present would be three times as much. There are difficulties in the way of such assumptions. It is curious that Köppen thinks that justice requires him to mention an obscure work, full of inaccuracies, whereas neither author mentions the classical paper

of George H. Darwin, "On the Influence of Geological Changes on the Earth's Axis of Rotation" (*Proc. Royal Soc.*, Vol. 25, 1876–77, pp. 328–332). Köppen reports at length a paper by G. V. Schiaparelli (1889), which, so far as I can judge from his account, is merely an elaboration of a part of Darwin's work. His argument is this, that though the axis of rotation of a rigid earth could not depart more than a few degrees from its axis of figure, as a result of any possible geological changes, the axis of a plastic earth could be changed indefinitely under a continuing cause. You will find that in Darwin. But where is the cause? It is easy to see from Darwin's calculations that if the North American continent were floated off from Europe to a distance of 90° to the west, the displacement of the pole would be only a few minutes of arc; which would, moreover, be partially counteracted by the simultaneous drift of South America. Such changes cannot occur repeatedly. What geological changes can be imagined that will continue to move the pole *in the same direction* through 65°? Our authors suggest none.

The hypothesis of the movements of the pole and the drift of the continents was adopted to fit certain facts, such as the reciprocal outlines of South America and Africa, the principal location of Permian glaciation, etc.; but, as has been shown, it does not fit other facts. As a further instance, the position of the north pole in Eocene time was placed about as far from Alaska as it now is, but on the other side. We should therefore expect a cold climate in Alaska during the Eocene; but this is just the time that the climate there was warmest, as far as we know. Our authors rely on many of the older estimates of geological temperatures, which require modifications in the light of later studies.

There have been many attempts to deduce the characteristics of the earth from a hypothesis; but they have all failed. There is the pentagonal system of Élie de Beaumont, the tetradedral system of Green; and others might be mentioned. This is another of the same type. Science has developed by the painstaking comparison of observations and, through close induction, by taking one short step backwards to their cause; not by first guessing at the cause and then deducing the phenomena.

HARRY FIELDING REID

## WALL ATLAS OF COMMERCIAL GEOGRAPHY

GEORGE PHILIP. **Philips' Comparative Wall Atlas of Commercial Development.** A set of eight maps, size 42 by 34 inches: (1) World, 1: 40,000,000; (2) Europe, 1: 6,000,000; (3) Asia, 1: 12,000,000; (4) Africa, 1: 9,000,000; (5) North America, 1: 9,000,000; (6) South America, 1: 9,000,000; (7) Australasia, 1: 6,000,000; (8) British Isles, 1: 1,000,000. George Philip & Son, Ltd., London, [1922.] 3s. 6d. each, unmounted.

Geography as an interpretative science is greatly indebted to the house of Philip. They gave us a few years ago an invaluable set of maps, the "Comparative Wall Atlas." In this set, for instance, the map of natural vegetation went beyond the miserable confusing designation that had been used so disappointingly before under the title of "woodland, grass, and cultivation." These maps are real geography in a visible, quickly understandable, and highly effective form.

The announcement of a new series was greatly anticipated by the reviewer, but he must confess to considerable disappointment. The purpose and method of construction of the present series of maps of commercial development were described and exhibited before the Royal Geographical Society some years ago (George Philip: A New Series of Economic Maps for School Use, *Geogr. Journ.*, Vol. 50, 1917, pp. 438–447). Mr. Philip then said: "How, then, within the limits imposed by the size to which a school atlas is restricted, and the number of maps which it can afford to devote to economic geography, can we prepare a really useful series of economic maps? After experimenting on various lines, I decided that the right method to adopt was to associate the distribution of the population with the nature of its economic activities. This conclusion meant in effect that the groundwork of the economic map should be formed by the combination of a map showing the density or distribution of the population and a map showing regional vegetation. Only by weaving together the materials supplied by these two maps did it seem possible to obtain the basis for a reliable representation of the progress achieved by man in his exploitation of the world and its resources, and of the general character of his various occupations."